Coastal Ocean Circulation Experiment off Senegal (COCES)

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http://poseidon.ogs.trieste.it/sire/drifter/coces_main.html

LONG-TERM GOALS

To investigate the dynamics of coastal areas dominated by buoyancy input and wind forcing, influenced by complex topography and interacting with the deep ocean. To improve the understanding of coastal marine environmental evolution, with particular emphasis on eddy dynamics.

OBJECTIVES

The general objective of the COCES project is to investigate the coastal dynamics off NW Africa in the tropical Atlantic Ocean. In particular, it is planned to study the near-surface dispersion and circulation off the coast of Senegal, a region strongly influenced by coastal upwelling dynamics and affected by the runoff of an important river, using drifter observations and ancillary satellite data (SST and ocean color) over about a year (from spring 2009 to winter 2010), in collaboration with local oceanographers.

APPROACH

Surface drifters will be deployed at key locations on the continental shelf and slope off Senegal to maximize the geographical coverage in the study area and to construct maps of mean circulation and eddy variability under winter (upwelling) and summer conditions.

Some drifters will be deployed near the vicinity of the mouth of the major rivers to study the river plume dynamics under several wind (e.g., NE upwelling favorable and SW downwelling favorable winds) and discharge rate conditions.

All the drifter data will also be analyzed in concert with satellite images (SST and ocean color) to describe qualitatively the surface dynamics, with particular focus on mesoscale circulation features such as eddies and filaments.

Training and capacity building activities are also proposed to teach Senegalese people to operate drifters, to process their data, and to analyze the scientific results obtained from them.

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WORK COMPLETED

SVP and CODE drifters were deployed off Senegal since May 2009 with the help of local oceanographers. In total, 31 drifters were released between 22 May 2009 and 21 July 2010 (see Table 1 for details on the deployment episodes). More than 1400 drifter-days worth of data were collected between May 2009 and September 2010. As of 30 September 2010, 4 SVP drifters are still operating in the tropical North Atlantic.

Date	Drifters deployed	Drifters alive on 30 Sep 2010
May 2009	3	0
November 2009	5	1
January 2010	3	0
February 2010	6	3
March 2010	8	0
April 2010	2	0
May 2010	2	0
July 2010	2	0
Total	31	4

Table 1. Status table for the drifters deployed off Senegal in the Atlantic Ocean since May 2009, updated on 30 September 2010.

Some drifters (SVPs) were deployed off Cap Vert (Dakar), using rented boats, and others (CODEs) between Dakar and the Casamanche River mouth using a ship-of-opportunity (Ferry boat). In particular, the P.I. went to Dakar in March 2010 to help the local oceanographers with the recovery of some units (Fig. 1) and their re-deployments off Cap Vert.

The COCES web pages were updated. They provide basic information on the project, near real time (updated on a daily basis) products such as graphs with drifter trajectories and with times series of position (latitude and longitude, speed, sea surface temperature, battery voltage, drogue presence parameter, etc.). A status table is also included to monitor the drifter array. The drifter positions have also been implemented in Google Earth (see Figure 1). The URL address of the COCES main page is: http://nettuno.ogs.trieste.it/sire/drifter/coces/coces_main.html

Drifter tracks were overlaid on satellite images of sea surface temperature, chlorophyll concentration and sea surface height to describe qualitatively the spatial structure and temporal evolution of the Levantine Sea dynamics. An example is illustrated in Fig. 3.

Pseudo-Eulerian statistics of the near-surface circulation were calculated using bins of 0.5 x 0.5. The mean near-surface circulation derived from the drifter velocities is depicted in Fig. 4.

Figure 1. Picture of the P.I. and Senegalese collaborators with two SVP drifters recovered in a fisherman village in early March 2010.

Figure 2. Trajectories of the SVP and CODE drifters in the eastern tropical Atlantic Ocean. Drifter identification numbers are posted at the end of the tracks. For units a92023, a92024, a92025 and a92028 they indicate the drifter positions on 30 September 2010.

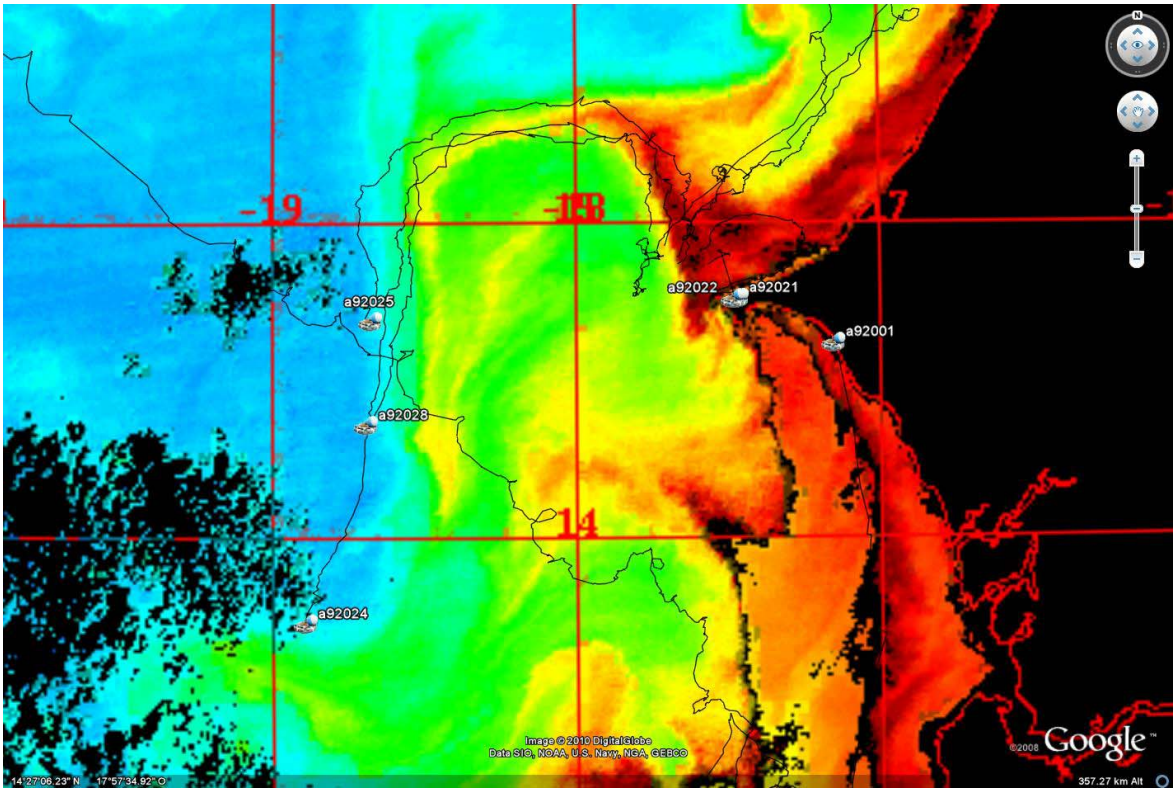

Figure 3. MODIS image of sea surface chlorophyll concentration on 19 February 2010 (blue and red colors correspond to low and high values of <Chl>, respectively) with superimposed drifter tracks. The offshore advection of the 3 drifters in a filament of upwelled waters is evident.

RESULTS

The SVP drifters deployed off Cap Vert (Dakar) generally moved westward, after an initial drift towards the northeast along the coast of Senegal for some units (Fig. 2). The drifters sampled the westward-flowing North Equatorial Current between 10°N and 22°N and as far west as 51°W (on 30 September 2010). For instance, drifter 92023 moved a distance of ~3500 km more than half-way across the Atlantic Ocean in about 10 months. Two drifters moved through the Cape Verde Islands. Three drifters left the North Equatorial Current near longitude of 30-32°W to join the North Equatorial Counter Current and proceed eastward along 7-9°N. Inertial motions are ubiquitous in the motion of this long-lived drifter, as depicted by the preponderance of small anticyclonic loops along its trajectory.

If we focus on the Senegalese coastal waters, the deployments performed off Dakar in February 2009 are particularly interesting since they correspond to the maximum upwelling season. Indeed, the cluster of drifters deployed on 6 February 2009 was entrained in the offshore flowing jet of relatively cold and nutrient-rich upwelled water. After an initial northward movement, the drifters turned cyclonically and subsequently progressed torward the south. There is a remarkable agreement between the drifter tracks and the satellite image of <Chl> on 19 February 2010 (Fig. 3).

The map of mean circulation constructed from the drifter data shows northward (southward) float in the Senegalese coastal waters, north (south) of Cap Vert. More offshore, mean zonal velocities in the North Equatorial Current and the North Equatorial Counter Current (east of 28°W) can be as large as 50 cm/s.

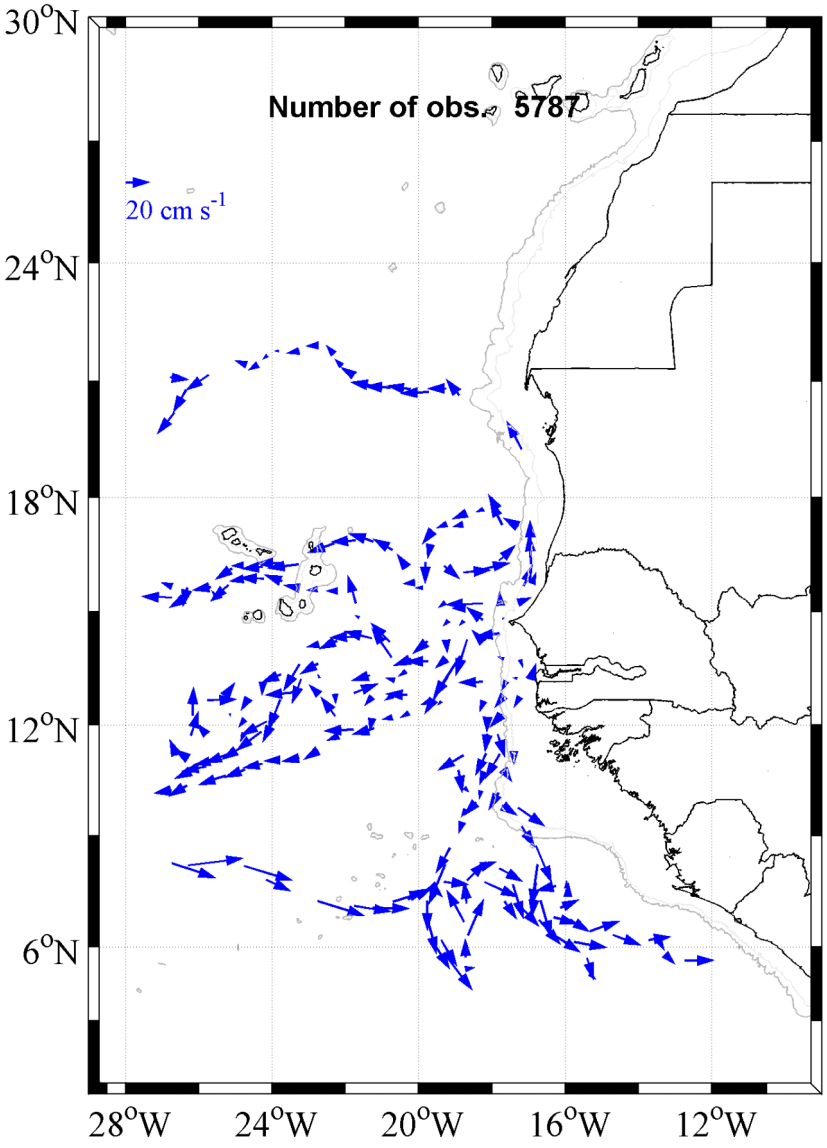

Figure 4. Mean circulation in the Tropical North Atlantic for the period May 2009 –September 2010. The mean flow arrows are centred at the centre of mass of the observations in each bin. Data are grouped into 0.5° x 0.5° bins. Bins containing less than 10 observations were rejected for the computation of the statistics. The 1000 m isobath is represented with grey curves.

IMPACT/APPLICATION

The scientific impact of this project is to increase our understanding of the coastal dynamics off NW Africa and its interaction with the tropical Atlantic Ocean. Future application could be the validation of

diagnostic numerical models and the assimilation of the drifter data into prognostic numerical models of coastal ocean circulation.

RELATED PROJECTS

In addition to national programs conducted by collaborators in Senegal, the COCES project is related to the Global Drifter Program (GDP) in the Atlantic Ocean (P.I. : Dr. R. Lumpkin, NOAA/AOML, Miami).

http://www.aoml.noaa.gov/phod/dac/gdp.html